MICROGRAVITY SCIENCES AND PROCESSES (A2)
Microgravity Sciences onboard the International Space Station and Beyond (6)

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NON MARANGONI MOTION OF A BUBBLE UNDER A TEMPERATURE GRADIENT

Abstract

The thermocapillary (Marangoni) motion of vapour bubble under a temperature gradient cannot be efficient in a pure, one component fluid. Indeed, in such a system, the gas-liquid interface is always at constant saturation temperature. However, evaporation on the hot side and condensation on the cold side can occur and displace the centre of mass of the bubble. Such a phenomenon has been observed in two quite different fluids, hydrogen and water. It is compared with existing theories and 1D numerical simulations. The experiments and subsequent analyses are performed in the vicinity of the gas-liquid critical point in order to benefit of its universality features. Experiments with hydrogen (H2, critical temperature: 33 K) have been performed in the facility of magnetic compensation of gravity at CEA-Grenoble. A transparent Plexiglas tube holds the liquid H2 with a small H2 bubble. Initially, both liquid and vapour are at the same temperature. Then the temperature of one or both ends of the tube is changed, resulting in temperature gradients between about 0.1 and 2 K/cm. Surprisingly, the bubble is seen to move immediately towards the hot end of the cell. The movement stops after a few seconds. The experiment with water near its critical temperature (647 K) has been carried out in the DECLIC facility onboard the ISS. A temperature gradient on the order of 0.08 K/cm is imposed in the fluid at 634 K. Then temperature is decreased from the supercritical, one phase state above the critical point, to the vapour-liquid state. During the process, a large bubble eventually forms that moves towards the hot end of the cell. In order to better understand the above phenomena, 1D numerical simulation is performed. It shows that, after the temperature gradient has been imposed, two regimes can be evidenced. At early times, the temperatures in the bubble and the surrounding liquid become different due to their different compressibilities and the "Piston effect" mechanism, i.e. the fast adiabatic bulk thermalization induced by the expansion of the thermal boundary layers. The bubble motion is seen to be induced by the different local temperature gradients as resulting from evaporation/condensation at the vapour-liquid interface. At long times, a steady gradient forms in the liquid (but not in the bubble) that induces steady bubble motion towards the hot end. The bubble velocity is evaluated and compared with existing theories.